The Ecological Monitoring Component of Environmental Impact Assessment in Antarctica.

A Review

Gareth Ward

GCAS 6

January 12th 2004

The ecological monitoring component of Environmental Impact Assessment in Antarctica

Abstract

Environmental Impact Assessment (EIA) is an integral part of the 1991 Protocol on Environmental Protection to the Antarctic Treaty. The ecological component of EIA is termed Ecological Impact Assessment (EcIA) and has been the subject of much worldwide research that has highlighted ecological monitoring as an area of concern. The concern lies with both the frequency with which monitoring is carried out, the quality of monitoring and the way the results are used to improve EcIA. This is particularly relevant in Antarctica where difficulties in implementing ecological monitoring are exacerbated by cost, ambiguity of language within the Protocol, limited habitat, lack of suitable terrestrial indicator species and a lack of baseline data. However some ecological monitoring is carried out providing useful baseline data and results for assessing the veracity of impact assessments. The Cape Roberts Project carried out a successful monitoring programme that showed the accuracy of the impact predictions made prior to starting the project

Introduction

This paper aims to review the legislative requirements for ecological monitoring as part of the Environmental Impact Assessment (EIA) process in Antarctica. I will then consider the best practice requirements for ecological monitoring as it is implemented elsewhere in the world, outline the difficulties of implementing good ecological monitoring in Antarctica, consider the monitoring that currently takes place and make recommendations for improving the ecological monitoring component of EIA in Antarctica.

Annex I to the Protocol on Environmental Protection to the Antarctic Treaty asserts the requirement for an EIA to be undertaken for proposed activities in Antarctica. In addition Annex I requires that mandatory environmental monitoring be carried out where an intermediate (IEE) or a comprehensive environmental evaluation (CEE) is undertaken.

The ecological component of EIA, termed Ecological Impact Assessment (EcIA) aims to assess the impact of a given project or activity on the flora and fauna of the project area and has been the subject of much research. The evidence suggests that it is an area which requires significant improvement in the majority of Environmental Statements (ESs) (Beanlands and Duinker 1984, Thompson *et al* 1997, Treweek 1996, Warnken and Buckley 1998). Ecological monitoring includes both monitoring species to gather baseline data and monitoring the actual impacts of a project on species and comparing them to the predicted impacts. Ecological monitoring is an area highlighted in the research as being of particular concern due to often being done badly, not at all or by unqualified practitioners. This research has led to the development of a set of "Common Procedural Steps in EcIA" (Treweek 1999).

In Antarctica ecological monitoring faces unique difficulties amongst which are the ambiguity of the language within the Protocol, the cost of undertaking any activities on the ice, the lack of ice free land and the accompanying lack of suitable terrestrial indicator species.

For some projects, particularly tourism projects the primary area of focus is not the continent itself - rather the coastal margins - and therefore there is a greater biodiversity to take into account. As a result it has been easier to conduct significant work to assess and monitor the impact of human interaction with the coastal fauna of Antarctica.

Few land-based projects have required a CEE, however, one notable exception to this is the Cape Roberts Project (1995 - 2001) which has been extensively monitored since its completion, providing a wealth of information on the accuracy of the impact predictions and of the reaction of the fauna to such a large project.

Legislative Requirements

The Antarctic Treaty which came into force in 1961 provides the basis for co-operation between all the countries involved in Antarctic activities. However it does not deal specifically with the issues of resource use and environmental protection.

In 1991 the Protocol on Environmental Protection to the Antarctic Treaty was negotiated and adopted in Madrid although it did not enter into force until 1998. Article 3 of the "Madrid" Protocol sets out the principles for environmental protection which are further elaborated in the five annexes. Annex I details the requirements for EIA and states that EIAs should be undertaken in accordance with appropriate national procedures which in the case of New Zealand sourced activities is the Resource Management Act 1991 (RMA) and in the case of the British activities is the Town and Country Planning Act 1988.

The RMA (section 35(2)) calls for three types of monitoring to be carried out which can be summarised as:

- State of the Environment monitoring to assess human relationships to the environment both in terms of impacts and dependencies.
- Performance monitoring to assess actual environmental changes against stated goals and objectives.
- Compliance monitoring to assess environmental changes to specific standards requirements or conditions (Gee 1998).

In the New Zealand context there is a further legislative consideration namely the NZ Antarctic (Environmental Protection) Act 1996 that enacts the Antarctic Treaty and other documents which require consideration. These include the:

- Antarctic New Zealand Environmental Strategy 1998; and
- Towards a Monitoring Programme for Antarctica New Zealand: A Discussion Document.

The objectives of these documents are broadly in line with the RMA that requires the gathering of information and the monitoring of compliance and effects. As a result the similarities between the requirements of the RMA and the Protocol mean that the domestic NZ model provides a useful basis on which to base the processes of EIA in Antarctica and the Ross Sea region in particular (ibid.).

In addition to the requirement to undertake an EIA to national standards the Protocol also contains its own requirements. Under Annex I EIA is required on all activities, however the level of assessment required varies. Initially a preliminary environmental evaluation (PEE) is carried out for all activities and is all that is required if a project is judged as having a less than minor or transitory impact. If the impact is judged in the PEE as being "minor or transitory" then an Initial Environmental Evaluation (IEE) is required. An IEE is required to state the measures put in place to assess and verify the impact of the activity and states that this may include monitoring. The third level of assessment or Comprehensive Environmental Evaluation (CEE) is required on all projects with a greater than minor or transitory impact and a CEE is required to identify measures including monitoring that will be taken to minimise or mitigate against the impacts (Hemmings and Roura 2003).

Further to this COMNAP have produced Guidelines for Environmental Impact Assessment in Antarctica (COMNAP 1999) the aim of which is to provide the basic elements for the development of the EIA process and to achieve a consistency of approach in fulfilling the obligations of the protocol.

These guidelines highlight the need for “the characterisation of all relevant … biological … elements or values in a given area… Such information should be quantitative where available and appropriate." Herein lies one of the major difficulties with achieving quality EcIA results in Antarctica and that is the data gaps in our ecological knowledge, in a lot of cases we simply do not know what is present.

Specifically the guidelines suggest that consideration of the existing environment should include:

- the biota (e.g. inventories of plant and animal species, populations and communities, and other important features such as the presence of breeding grounds.) and
- any dependent and related populations (e.g. bird nesting areas related to feeding areas)

Concerning monitoring the guidelines indicate that “monitoring should be oriented towards confirming the accuracy of predictions about environmental impacts of the activity, and to detect unforeseen impacts or impact more significant than expected”.

Hence it can be seen that there is a requirement and an expectation that ecological monitoring be carried out for activities undertaken in Antarctica.

EcIA Best practice requirements

The requirement for environmental impact assessment and monitoring is entirely in line with the ideal common procedural steps for EcIA developed by Treweek (1999). Treweek states that EcIA should be based on assessment and evaluation that is informed by results of reliable monitoring. Ideally all the studies undertaken as part of an EcIA should be part of a coherent monitoring programme and should begin early in the project cycle so that it is possible to characterise the baseline conditions and to distinguish between the consequences of natural variation and the impacts of the project.

Although not designed specifically for the Antarctic situation Treweek's ideal steps are consistent with the National Research Council (1993) which states that an effective Antarctic monitoring programme should aim (*inter alia*) to provide an understanding of the dynamics and controlling processes of the major environments ecosystems as well as to determine the extent of contamination of Antarctic environments associated with human activities.

Impact prediction is often made with considerable uncertainty but is one of the most important steps in EIA or EcIA. This uncertainty derives from a number of sources such as the complexity of ecosystems, sampling limitations and a lack of opportunity for follow up monitoring. Treweek (1999) suggests that for impact prediction to have any validity it is necessary to understand ecosystem function in order to adequately explain and account for changes that have been observed. She also says that the ecological process that will drive any change need to be defined and existing variability accounted for so that changes can be attributed to defined actions or stressors.

In order to achieve this it is necessary to undertake baseline studies to characterise the condition and state in the absence of the proposed project of potentially affected ecosystems and then to identify and predict the impacts on selected ecosystem components by comparing them against the established baseline.

Monitoring should therefore strengthen the knowledge base and provide opportunities for corrective action in the light of unforeseen outcomes and allow feedback to assess the project implementation and compliance (Treweek 1999).

Monitoring provides us with vital information without which the ecological basis for impact prediction will be limited due to the high levels of uncertainty involved.

However, in Antarctica and elsewhere the EIA process is used largely to gain permission to undertake a project and ecological monitoring is kept to a minimum. One notable exception to this has been the Cape Roberts Drilling Project 1995 to 2001 that implemented a comprehensive monitoring programme that included vegetation and skua studies (New Zealand Antarctic Institute 2001).

Difficulties

There are significant difficulties with undertaking meaningful ecological monitoring in Antarctica, and these can be divided under two headings; systemic difficulties and Antarctic specific environmental constraints.

Systemic Difficulties.

Systemic difficulties relate to issues with how the monitoring is initiated, undertaken and reported.

The Madrid Protocol is implemented through national legislation. However, many of the Consultative parties that ratified the Protocol have not completed their implementing legislation and even when it has been enacted it may take time before the regulatory framework is in place (Kriwoken and Rootes, 2000).

The variability of interpretations under the differing national legislation has been exacerbated by the ambiguity of the language used in the EIA provisions of the Protocol. Phrases such as “a minor or transitory impact”, “significant changes” and “detrimental changes” are open to interpretation and have a direct bearing on the type and detail of any monitoring programmes that are initiated. This is further compounded by the lack of quantitative standards to determine the precise nature of the impacts (Ibid.). If a project is judged as having a less than minor or transitory impact then the environmental assessment need not progress further than a PEE and as a result no monitoring is required. But with no quantitative standards to assist in judging the impacts both the country undertaking the assessment and those assessing the PEE have no formal way of knowing if the assessment is accurate and therefore whether the requirement for monitoring is correct.

A further lacuna within the EIA requirements that may allow projects to slip through on a PEE is the absence of lists and schedules of activities that automatically require a secondary level of assessment. Such lists are often found in domestic legislation but are missing from Antarctic legislation.

To be most effective monitoring needs to be co-ordinated and standardised if regional or temporal trends are to be determined (SCAR/COMNAP 1996). However, although national programmes undertake localised assessments there is little coordination of methodologies, study designs or data interpretations which makes it very difficult to identify regional or temporal trends.

Antarctic Specific Environmental Constraints

Antarctic specific environmental constraints relate to the difficulties of undertaking ecological monitoring in Antarctica due to issues unique to working in the Antarctic environment.

The primary concern when monitoring impacts on local biota is a consideration of the geographical location of the project. For example it is considered impractical to use biological indicators for monitoring any activities on perennial ice or on the ocean (ibid.), which limits environmental monitoring to areas of sea ice and the very limited areas of ice free ground (less than 2% of the whole Antarctic continent).

Even when we consider the ice-free areas, plant life is impoverished and consists of a patchy distribution of algae, mosses, lichen and grasses. Except for a few insects, animal life is sea or airborne and migratory (Kriwoken and Rootes 2000). As a result suitable indicator species or subjects for monitoring may not be available.

A further concern is the lack of baseline knowledge on many of the species that may be considered for monitoring purposes. Article 3.2 (c (v)) of the Protocol makes a reference to the capacity to monitor and implies that baseline information on which to build may not always be available. This is not to suggest that monitoring should not be undertaken but that a clear indication of the inadequacies of the baseline data should be made both when trying to predict impacts and to report back on monitoring activities (SCAR/COMNAP 1996).

This is of concern where projects are assessed by predicting the impacts before the project is undertaken. The project is then monitored and the impacts assessed to see if the original predictions were correct. This is obviously impossible if there is no baseline data on the populations that are being monitored. Tourism activities are an area where the need for monitoring has been identified but problems arise as many tourism activities are already in operation and therefore it is impossible to assess the original baseline conditions and therefore no ' initial environmental reference state' can be provided. Effectively then, any monitoring which takes place is assessing the predicted impacts against an already impacted environment.

In addition the basic identification of some organisms may prove difficult and the natural variability of indicators based on species such as seals and penguins may make meaningful inferences from population dynamics difficult to interpret (Ibid.).

The lack of ecological baseline knowledge can also make it very difficult to discern cause and effect relationships in relation to changes in populations and/or species. Caution is required in making these linkages without considerable supporting evidence (Ibid.).

As an example of this problem the Ross Sea Region 2001: A state of the environment report for the Ross Sea region of Antarctica states (pg. 4.49) that:

> "Other than on a broad-scale survey, there is little detailed information on the biota of many of the ice-free areas of Ross Island … Substantial work is needed in the areas of taxonomy, species distribution, survival and adaption, ecophysiology and impact assessment … more research is needed on all species of the Ross Sea region if we are to discover which are the more useful for monitoring." (Waterhouse, 2001)

This is highlighted by Gee (1998) who states that:

> " Two of the more [important] aspects of the environment monitored, which New Zealand does not undertake, are nearshore coastal ecosystems (beyond simply measuring sewage output, which the majority of nations do) and animal populations."

Existing Monitoring

As discussed there are significant difficulties in implementing good monitoring practice. Therefore it is important that the results of existing monitoring are taken into account during the completion of an EIA / EcIA. Some examples of existing monitoring are outlined below.

Skua Monitoring

Skua populations have been widely studied in both the Antarctic and the sub-Antarctic (*inter alia* Hemmings 1990 and Young 1990). Skuas are the top avian predator in the Antarctic and sub-Antarctic and are therefore few in number and hence vulnerable to impacts which may appear trivial (Hemmings 1990).

Some evidence suggests that skuas adapt well to human presence with no identifiable impact (Young 1990). However, Hemmings (1990) suggests that human impact may not be so benign. Human activity may have the effect of enhancing food availability and therefore the chances of skua raising a second chick with a consequent increase in population. This may in turn have a negative effect on the skuas more traditional prey, such as penguins, which may already be stressed due to other human impacts.

Additionally, skuas are conservative in their choice of nesting sites and do not easily migrate between areas, hence any increase in adult mortality in one area cannot be easily mitigated by an influx of skua from another location and will therefore have a severe implications for the local skua population (ibid.).

Penguin Monitoring

Penguins (*Psygoscelis adeliae and Aptenodytes forsteri*) have been widely studied with regard to human impact (*inter alia* Fraser and Paterson 1997, Geise 1996, Geise 1998, Geise and Riddle 1999, Giese *et al* 1999, Thomson 1977, Young 1990).

Findings of these studies have provided substantial data on the existing state of penguin colonies and their current behaviour patterns. Additionally the studies have indicated that penguins are susceptible to disturbance from human intrusion but the level of impact may vary. For example, the high level of disturbance experienced by the Cape Royds colony (Thompson 1977) caused a rapid decrease in population numbers with a 50% decline in breeding pairs between 1956 and 1963. Since restrictions came into force in 1963 and in 1968 caretakers were put in place to oversee visits to the Cape. Since then breeding pairs have increased with Thompson (quoted in Tracey 2001) stating:

> "evidence suggests almost conclusively that the sharp decline in penguin numbers can be attributed to the nearly constant interference by visitors on foot and more significantly to helicopters flying low over the rookery and landing within 100m".

Whereas studies near Palmer Station (Fraser and Patterson 1997) have indicated that

> "the potentially adverse effects of tourism and research may be negligible relative to the effects imposed by long-term changes in other environmental variables".

Overall the penguin monitoring studies have provided vital baseline information and shown that substantial levels of human activity can have serious negative consequences on penguin populations. However, studies are yet to establish conclusive evidence that less intrusive human activity causes significant levels of harm to penguin colonies.

As a result these studies have enabled researchers to suggest guidelines for human interaction with penguins to minimize negative impacts.

Terrestrial Flora

As has been indicated terrestrial flora is limited, therefore limited monitoring has been undertaken. One exception to this is the work carried out by Dr P. Broady in 1993/94 (Broady P. lecture notes 2003 and quoted in Kallqvist 2002). The purpose of this work was to establish whether the site at Cape Geology is as rich in algal species as it is in mosses and lichens. As well as establishing a baseline additional monitoring was possible which showed the extremely slow growth of lichens in Antarctica. Boulders are still present which were photographed by western geological party of Scott's 1910-1913 *Terra Nova* expedition. Lichens on these rocks were compared to the lichens visible on the early 20th Century photographs and no visible change was apparent in the shape or size of the lichens indicating their extremely slow growth.

The results of the monitoring work at Cape Geology not only established baseline information and gave a vivid indication of the vulnerability of terrestrial flora in Antarctica but also allowed recommendations to be made on mitigating human impacts on terrestrial flora in Antarctica. These include limiting human activity to a flora poor area along the beach and up to 10-20m inland and where visits to the flora rich areas are necessary movement should be limited to boulders and rock outcrops where possible.

Case Studies of Monitoring Activities included in Two IEES and the monitoring of the Cape Roberts Drilling Project and Penguin Studies

The IEE for the construction of a new warm store facility, Scott Base, Antarctica (NZ Antarctic Institute 2003)

This IEE illustrates how the lack of baseline data hampers the EIA process. In Chapter 4 'Initial Environmental Reference State' Section 4.3 states that "Invertebrates in this area are little understood" and this is at a site that has been associated with base activities for over 46 years.

So we are immediately aware that any predicted impacts are likely to be open to a significant margin of error, as no one knows what is present in the first place. Therefore it is of no suprise when we read in Section 6.2 that "Little is known about the impact of earth moving activities on the invertebrate fauna (if present) although some impact could be expected".

As a result of this limited knowledge no invertebrate monitoring is suggested in Section 7, hence the baseline condition will never be known and an opportunity for enhancing the knowledge of invertebrates in Antarctica has been lost. It must be remembered that bases compete with most other terrestrial life forms for the scarce ice-free land in Antarctica so any loss of opportunity for monitoring is relatively serious.

The IEE for the Latitudinal Gradient Project, Cape Hallett Camp, Antarctica (LGP 2003)

This IEE document makes use of the existing baseline data to describe the initial environmental state in terms of avifauna, flora, terrestrial invertebrates and marine biology. The report makes it clear that some level of impact on the flora and fauna on and around Cape Hallett can be expected from the project and suggests ways of mitigating against these to ensure that the effect is minimised.

There is however no suggestion that the predictions made concerning the scale of the impacts will be tested by monitoring either the flora or the fauna during the project cycle. As a result no knowledge will be gained concerning the veracity of the impact predictions. Monitoring of these hypotheses would provide information that would be of direct benefit to future impact assessments and ensure the continued improvement of these documents.

The Cape Roberts Project 1995 - 2001, Antarctica (NZ Antarctic Institute 2001)

The Cape Roberts Project was subject to a CEE in 1994 that in accordance with the Environmental Protocol required a comprehensive monitoring programme to be carried out for the duration of the project. In 2001 the Final Environmental report was published (NZ Antarctic Institute 2001).

The ecological monitoring programme included assessments of the degree of disturbance on vegetation and skua breeding in the project area. Existing monitoring

was taken into account and project specific studies were set up. The results of this monitoring have indicated that the actual impacts of the project have conformed to the predicted impacts and that only minor and transitory impacts to the environment have occurred as was predicted.

The Cape Roberts experience clearly shows the benefit of undertaking a comprehensive monitoring programme. The assumptions used to assess the impacts have been proved correct in this case and can, if backed up with site specific information, be extrapolated to some extent to similar projects in similar areas with similar environmental variables.

Conclusions

Ecological monitoring is an integral part of the Antarctic EIA process as envisaged by the 1991 Protocol. But due to the unique difficulties of working in Antarctica and in common with EIA elsewhere in the world it is difficult to implement and is therefore often sidelined. However best practice guidelines and the evidence of existing monitoring suggests that the more often ecological monitoring activities are undertaken the greater the body of knowledge available to those undertaking environmental assessments and therefore the greater the certainty that the predictions will prove to be correct. Without this information the environmental impact assessment will always be relying on qualitative data and judgement calls by those people compiling the reports.

Therefore it is recommended that New Zealand, which has a reputation for "punching above its weight" in Antarctica, does so again and leads the way in implementing studies to assess the actual ecological impacts of past projects. This could take the form of a PhD to monitor past project sites against the predicted impacts in the EIA documents produced at project inception.

In this way actual quantitative data could be gathered allowing both quantitative standards to be put in a place to assist in judging the predicted impacts as well as producing schedules of activities that automatically require an IEE or CEE. Additionally, such a project would provide valuable baseline data for use in assessing future projects.

If the standard of ecological monitoring in Antarctica is not improved there is a real potential for significant negative impact on this unique ecosystem to go unnoticed.

REFERENCES

Beanlands, G.E. and Duinker, P.N. (1984) An ecological framework for environmental impact assessment *Journal of Environmental Management* **18**, 267-277.

COMNAP Committee of Members of National Antarctic Programs (1999) Guidelines for Environmental Impact Assessment in Antarctica. COMNAP, Hobart, Tasmania Australia.

Fraser, W. and Patterson, D (1997) Human Disturbance and Long-Term Changes in Adelie Penguin Populations: a Natural Experiment at Palmer Station, Antarctic Peninsula. *Antarctic Communities: species, structure and survival,* Battaglia, B. Valencia, J and Walton, D. Cambridge University Press, Cambridge.

Gee, R.J. (1998) Environmental Monitoring in the Ross Sea Region: Towards Integration. Unpublished MSc Thesis Lincoln University.

Geise, M. (1996) Effects of Human Activity on Adelie Penguin *Psygoscelis adeliae* Breeding Success. *Biological Conservation* **75** :157 -164.

Geise, M. (1998) Guidelines for people approaching breeding Groups of Adelie Penguin (*Psygoscelis adeliae*). *Polar Record* **34** (191): 287 - 292.

Geise, M. Handsworth, R. and Stephenson, R. (1999) Measuring Resting Heart Rates in Penguins Using an Artificial Egg. *Journal of Field Ornithology* **70**(1):49-54.

Geise, M. and Riddle, M. (1999) Disturbance of Emperor Penguin *Aptenodytes forsteri* Chicks by Helicopters. *Polar Biology* (1999) **22** :366-371.

Hemmings, A.D. (1990) Human Impacts and Ecological Constraints on Skuas. *Antarctic Ecosystems. Ecological Change and Conservation.* Ed. Kerry K.R. and Hempel G. Springer - Verlag Berlin Heidelberg 1990.

Hemmings, A.D. and Roura, R. (2003) A square peg in a round hole: fitting impact assessment under the Antarctic Environmental Protocol to Antarctic tourism. *Impact Assessment and Project Appraisal* **21**(1) 13 -24.

Kallqvist, E. (2002) Monitoring Footsteps in the Ross Sea Region: Is It Possible to Monitor the Impacts From Tourism in the Ross Sea Region? *LIA Rapport HT-2002* Stockholm Environmental Centre. Supervisor Professor Bryan Storey, Gateway Antarctica, University of Canterbury.

Kriwoken, L.K. and Rootes, D. (2000) Tourism on Ice: Environmental Impact Assessment of Antarctic Tourism. *Impact Assessment and Project Appraisal* **18**(2) 138-150.

LGP (2003) Latitudinal Gradient Project, Cape Hallett Camp Initial Environmental Evaluation June 2003

National Research Council (1993). *Science and Stewardship in the Antarctic*. National Academy Press, Washington DC

New Zealand Antarctic Institute (2001), Cape Roberts Project Final Environmental Report, Antarctica New Zealand, Christchurch, New Zealand.

New Zealand Antarctic Institute (2003), The IEE for the construction of a new warm store facility, Scott Base, Antarctica, Antarctica New Zealand, Christchurch, New Zealand.

SCAR and COMNAP (1996) Monitoring of environmental impacts from science and operations in Antarctica: A report.

Thompson, R. (1977). Effects of Human Disturbance on and Adelie Penguin Rookery and Measures of Control. *Adaptions within Antarctic ecosystems: proceedings of the 3rd SCAR symposium on Antarctic Biology,* 26 - 30 August, Smithsonian Institute, Washington D.C. Quoted in Tracey, P.J. 2001.

Thompson, S., Treweek, J.R. & Thurling, D.J. (1997) The ecological component of environmental impact assessment: a critical review of British environmental statements. *Journal of Environmental Planning and Management* **40** (2) 157-171.

Tracey, P.J. (2001) Managing Antarctic Tourism. PhD Thesis, Institute of Antarctic and Southern Ocean Studies, University of Tasmania.

Treweek, J.R. (1996) Ecology and environmental impact assessment. *Journal of Applied Ecology* **33** 191-199.

Treweek, J.R. (1999) Ecological Impact Assessment. Blackwell Science, Oxford, UK .

Warnken, J. and Buckley, R. (1998) Scientific quality of tourism environmental impact assessment. *Journal of Applied Ecology* **35** 1-8.

Waterhouse, J.W. ed. (2001) Ross Sea Region 2001: A State of the Environment Report for the Ross Sea Region of Antarctica. Antarctica New Zealand, Christchurch, NZ.

Young E.C. (1990) Long-Term Stability and Human Impacts in Antarctic Skuas and Adelie Penguins. *Antarctic Ecosystems. Ecological Change and Conservation.* Ed. Kerry K.R. and Hempel G. Springer - Verlag Berlin Heidelberg 1990.